

Approximation to the extreme events analysis as climatic change evidence

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1. Abstract

An alteration evidence of natural climate variability as a consequence of the human action is the increment in the occurrence frequency and intensity of extreme events related with hurricanes and tropical storms. In this sense, the present investigation applied a simple approach of the frequency analysis of such events occurs during the period 1971-2006 in the Caribbean Sea and Atlantic Ocean. Once obtained the data via Internet from the National Center of Hurricanes of Miami attributed to the NOAA, were analyzed total events and two sub periods: 1971-1989 and 1990-2006, starting with the Probability Density Function (PDF), where data follows a Gamma distribution; besides were applied statistical tests for means and variances accumulated contrast.. In conclusion, for each sub period, a numeric mean increment is evidenced, for hurricanes (4,8 at 6,6), tropical storms (3,2 at 5,1) and total extreme events (8,3 at 12,0), as well as for the variances: hurricanes (1,6 at 2,8), tropical storms (2,0 at 1,9) and total extreme events (2,7 at 3,8). Nevertheless, although such increments are not still statistically significant (hurricanes - 11%, storms - 44%, total - 22,4%) the displacement is evidenced to critical probabilities (5 - 10%), reason for the Intergovernmental Panel for the Climatic Change (IPCC – 2007) was not conclusive regard this aspect. It was also obtained that the trend of the storms and total events are growing and presents significant differences between decades 1970-1980-1990 with 2000 that presents a bigger number of extreme events, possibly related with actual level changes of global climate.

2. Introduction

In the climatic system occur permanent intrinsic variations due to the climatic factors characteristics, that originates manifestations reflected in behavior changes of meteorological elements. However, in the course of the time, climate changes have affected the natural dynamic of the climate in the planet. The increase of the mankind vulnerability with the global changes has led international organizations as the Intergovernmental Panel on Climate Change (IPCC) and researchers of diverse world institutes and universities to quantify the magnitude and the trend of the climatic change. One change that we can appreciate in this century is the increase in frequency and intensity of extreme events that affect human activities. Within these events, the occurrence of hurricanes and tropical storms in the Caribbean Sea and Atlantic Ocean has vital importance to this region inhabitants, that induce to evaluate the behavior of these events. During the summer of the north hemisphere, the hurricanes provoke devastation in the islands and coasts of central and north of the American continent, like in the south-oriental islands and coasts of Asia. Katrina and Rita were the most destroyer events occurs on 2005. The hurricanes formed from a cyclonic circulation on the ocean, as an air vortex that turns about a zone of low pressure, with high superficial temperatures $> 26^{\circ}\text{C}$ (Webster et al, 2005) and without wind (calmness) conditions that characterize the tropical oceans and specially the Caribbean Sea.

Emanuel (1987) mentioned that global climate models showed a substantial increase in potential intensity with anthropogenic warming, leading to the prediction that actual storm intensity should increase with time. In a recent study, Emanuel (2005) indicated the increasing destructive power of the hurricanes over the past 30 years, induced not only by the thermal increase of tropical sea surface ($> 0,5^{\circ}\text{C}$), but included an increase on wind speed and whole temperature profile of the troposphere. In this sense, Webster et al (2005) expressed the increase of the hurricanes number of 4 and 5 category, that is to say those more destructive, which passed from 20% through 70's to 35 % in the last 15 years (1990-2005).

Related to extreme events, the IPCC (2001) consider the last XX century as the period when it have been presented with more frequency: the increase phenomena of extreme temperatures as well as more events of torrential rains; also, the Panel analyzed the future risk that means this changes in terms of duration, frequency and intensity of the climatic extreme events under conditions of climatic change, concluding that it's happening significant changes in the climatic variability and extreme events. Under this premise, presently work intends an approach of frequency extreme events analysis, mainly of hurricanes and tropical storms occurs during the period 1971-2006.

3. Methods

The hurricanes and tropical storms data were obtained via Internet from database of the Miami National Center of Hurricanes attributed to the NOAA (National Oceanic and Atmospheric Administration) and were built the charts corresponding to its frequency for the selected period. The IPCC (2001, 2007) recommends the Probability Density Function Analysis of the extreme events (PDFA) with adjustment to a normal distribution, a difficult task with few quantity of information (36 years). This analysis was carried out for two sub-periods: 1971-1989 and 1990-2006, and for total extreme events. Also, it was determined the trend in the occurrence frequency of hurricanes and tropical storms by means of linear regression models adjustment and the contrast of accumulated means and variances. Finally, the frequencies of hurricanes, tropical storms and total events were compared statistically with Kruskal-Wallis Non Parametric Tests (Siegel and Castellan, 1988), to examine means differences and variances differences. The data process was carried out with the software Statistica V 7.0. (Statsoft 2005) and Excel (Microsoft Office 2003).

4. Results

The Probability Density Function Analysis of the extreme events (PDFA) demonstrated that the best adjustment achievement with the Gamma distribution (Fig. 1), which is highly associated to the normal distribution.

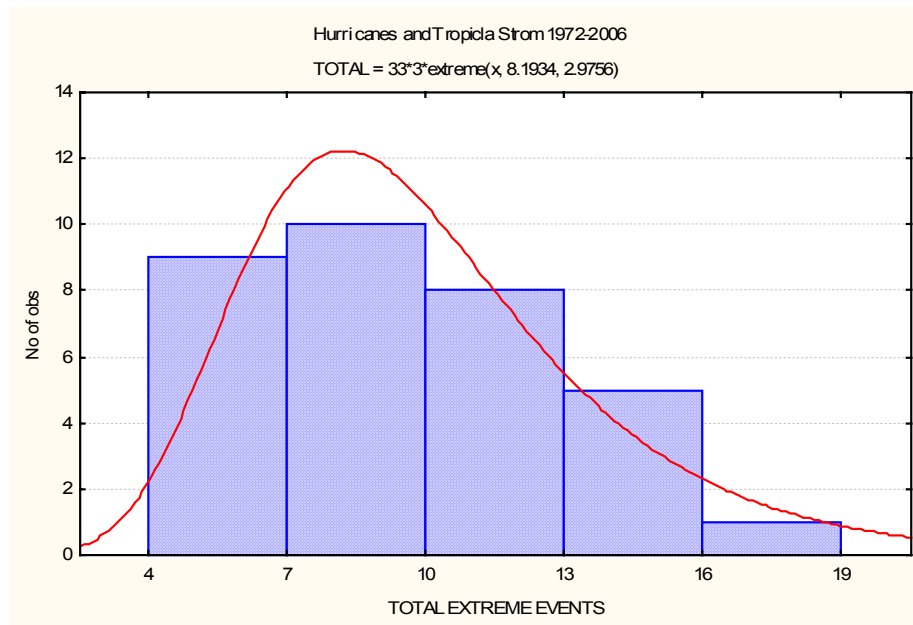


Figure 1 Adjustment of hurricanes and tropical storms frequencies (obs) to a Gamma distribution

The analysis of frequencies trend was carried out for sub-periods of 9 years before 1990 and 8 years to posteriori (Fig. 2). A clear upward tendency is observed in the hurricanes and storms frequencies that allowed the adjustment of the minimum square model whose explained variance reaches 74% for the hurricanes and the 95% for tropical storms. It was also obtained high values of the regression coefficients, specifically in the slope, indicating a change rate of 6,5 for the hurricanes and 9,7 for the tropical storms, showing the hurricanes trend to increase in 6,5 events in 8-9 years periods, while the tropical storms will be increased in 9,5 events for the same period.

The analysis of accumulated means is shown in Figure 3, where an upward tendency is evidenced and indicates the average increment of 1 extreme event for 10 years period; however, when observing the tendency of the accumulated variances, it's possible appreciate the higher variability tendency of these events, with 4 events for 10 years period, with maximum in 2005. This implies that fluctuations of the extreme events will be more heterogeneous in the future, and indicates bigger variability in the occurrence of these events with more risk for the next years.

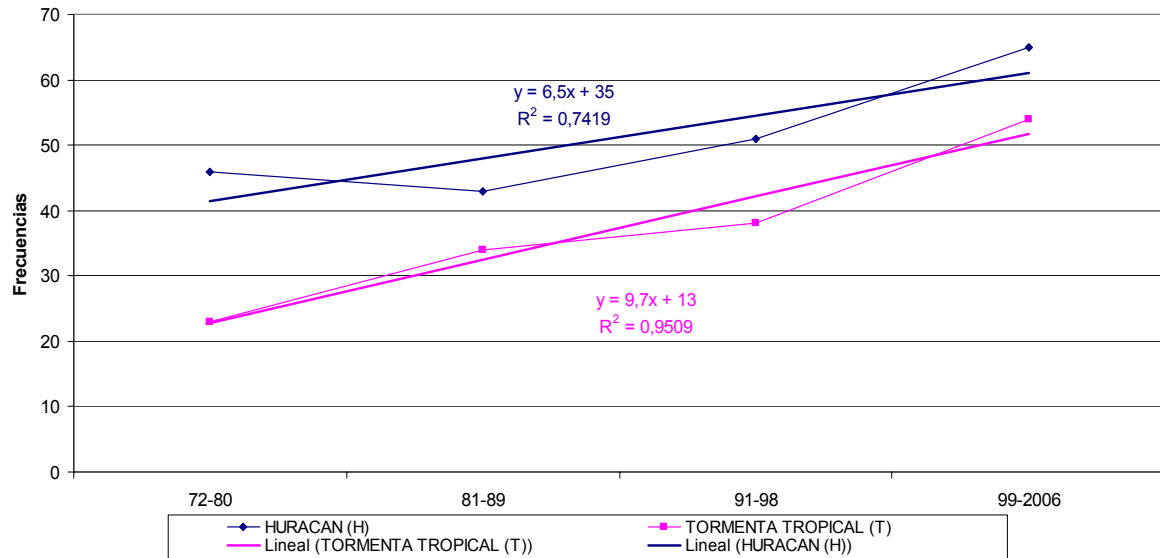


Figure 2 Trend analysis of hurricanes and tropical storms frequencies

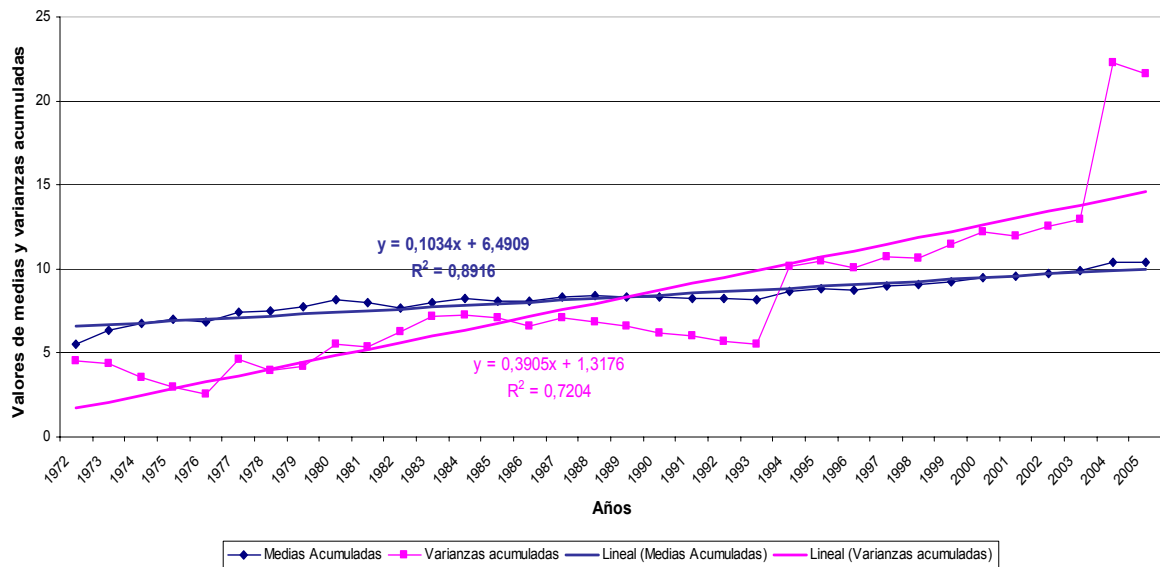


Figure 3 Trend of accumulated means and variances

For each sub period, a numeric increment of the hurricanes mean is evidenced (4,8 at 6,6), tropical storms (3,2 at 5,1) and total extreme events (8,3 at 12,0), as well as for hurricanes variances (1,6 at 2,8), tropical storms (2,0 at 1,9) and total extreme events (2,7 at 3,8). Nevertheless, although such increments are not still statistically significant (hurricanes - 11%, storms - 44%, total - 22,4%) the displacement is evidenced to critical probabilities (5 - 10%), reason for the Intergovernmental Panel for the Climatic Change (IPCC) in its 2007 report is not conclusive respect with this aspect

In Figures 4 and 5 the boxes increment corroborate the high occurrence of extreme events, although only it was represented the tropical storms and total events, because the hurricanes didn't present a significant trend in this analysis.

In conclusion, total extreme events data were adjusted to a Gamma distribution, which in specific conditions is in sync to a normal distribution. Evidently, exists an increase in the hurricanes frequencies and tropical storms in the considered period, accompanied by the increment in its variability. Equally, significant differences appreciated in the number of total events and tropical storms among this decade's 70-80-90 and 2000 reinforces the growing tendency in the occurrence of extreme events that can be associated to the climatic changes.

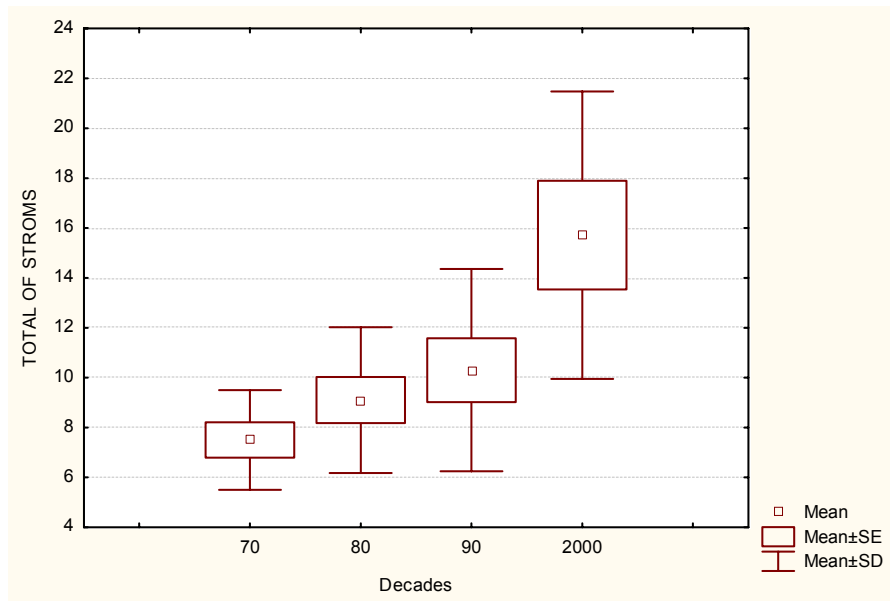


Figure 4 Frequencies comparison of tropical storms per decades

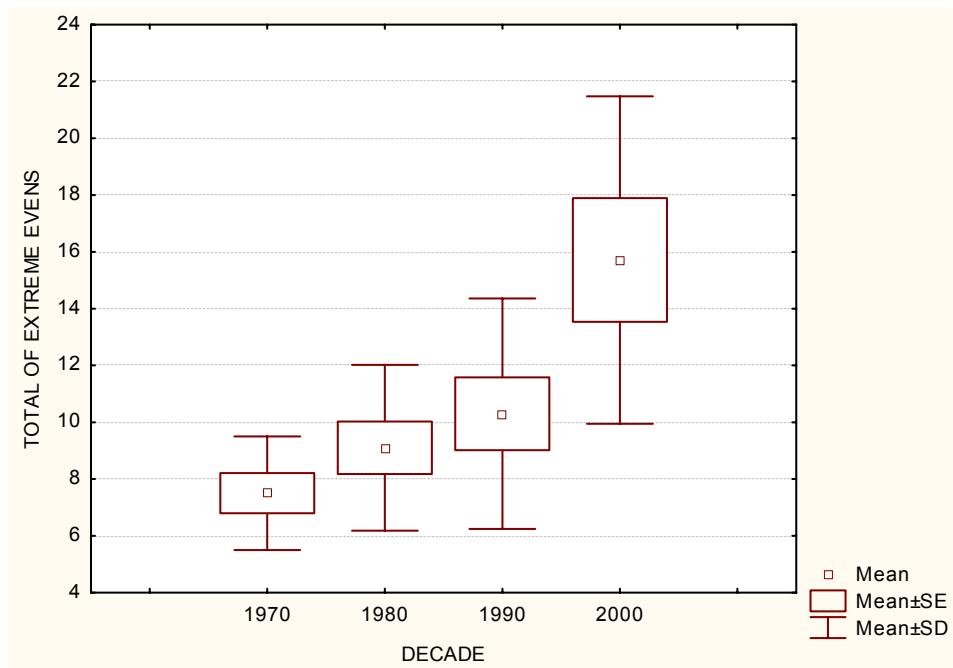


Figure 5 Frequencies comparison of total extreme events per decades

5. References

- Emanuel, K., 1987. The dependence of hurricane intensity on climate. *Nature*, 326: 483-485.
- Emanuel, K., 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, 436; doi 10.1038/nature03906.
- IPCC, 2001. Tercer Informe de Evaluación. Cambio Climático 2001: La base científica.
- IPCC, 2007. Cuarto Informe de Evaluación. Cambio Climático 2007. La base científica. <http://www.ipcc.ch>
- National Oceanic and Atmospheric Administration (NOAA) <http://www.noaa.gov/>
- StatSoft, Inc, 2004. STATISTICA (Data Analysis Software System), version 7. <http://www.statsoft.com>.
- Siegel, S. and Castellan, N. J., 1988. Nonparametric statistics for the behavioral sciences (2nd ed.) New York: McGraw-Hill.
- Webster, P.J., Holland, G.J., Curry, J.A. and Chang, H.-R., 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309, 1844; doi 10.1126/science.1116448. (<http://www.sciencemag.org/cgi/content/full/309/5742/1844>)